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Response of East Texas Mid-Rotation Loblolly Pine Plantations to Poultry Litter and Chemical Fertilizer Amendments

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Abstract

Improving site quality with fertilization is a common forestry practice. Where poultry production occurs, a common issue is the disposal of the poultry litter, which can cause nutrient overload on some soils. Forest plantations offer an alternative litter disposal site, while providing for possible tree growth increases similar to those found with chemical fertilizers. To test that hypothesis, 3 sites in east Texas, USA supporting loblolly pine (*Pinus taeda*) plantations were treated at poultry or chemical fertilizers at mid-rotation, and the growth responses recorded over a four-year period. Only one of the three sites showed any growth response in quadratic mean diameter growth attributed to poultry litter, and that was only after four years. No other response was found significant, suggesting that longer-term responses may occur than what this study captured. Poultry litter, if economically feasible, does appear to be an alternative to petro-chemical fertilizers on these sites.

Keywords: Fertilization; Poultry litter; Loblolly pine; Site quality

Introduction

Poultry or Broiler litter is a combination of poultry manure, bedding material, feathers and spilled food. In the United States, poultry litter production exceeds 10 million metric tons annually, and exceeds the levels of nitrogen (N) and phosphorus (P) which can be applied to lands in close proximity to poultry farms. While application of poultry litter may enhance soil properties, excessive amounts may cause soil and water degradation [1-3]. The 11.7 million hectares of loblolly pine (*Pinus taeda* L.) plantations found in the southern United States are a potential market for poultry litter as an alternative to chemical fertilizers. To be an alternative to chemical fertilizers, poultry litter must be economically feasible, both in its application in plantations and in the resulting growth rates of loblolly pine. Many studies have investigated the composition of poultry litter [4-8], as well as application and vegetation response to various quantities and combinations [2,3,9-13], and some management protocols on various soils have been established.

While most studies have focused on agricultural non-woody crops, a few in east Texas have investigated woody vegetation. Results tended to vary widely based on soil characteristics, soil fertility and stage of growth of the woody plant, usually mid-rotation for pine plantations [11,14].

The objective of this study was to evaluate and compare the growth response of east Texas loblolly pine (*Pinus taeda* L.) plantations to commercial fertilizer and poultry litter at mid-rotation.

Materials and Methods

Study sites

The study was conducted in three east Texas pine plantations (designated Lufkin, Broaddus, Wells) within a 30-kilometer radius of each other. The mid-rotation sites were 12-17 years old and thinned to an estimated basal area of 5.26 m^2 ha^{-1} with a density of 188 trees ha^{-1} with 91.4 m × 21.3 m plots in a randomized block design. Sites were not blocked based on soil characteristics (Table 1), and management activities at some of the sites (Broadus mid-rotation harvested before ending of this study, introduced some confounding variables into our assessments. The data was collected from several long-term repeated measurement studies with a variety of treatments utilized (Table 2).

Measurements

Measured parameters during six dormant seasons included diameter at breast height (nearest 0.1 cm at 1.37 m above ground (DBH)), root collar diameter (nearest 0.1 mm (RCD), total heights (nearest 0.5 m), and soil series mapping unit.

From these parameters, quadratic mean diameter (cm (QMD)), mean height (m), Basal area (BA), and volume (m^3 ha^{-1}) calculated. Dead trees were tallied but not used in data analysis. Soil series were identified by plot using USDA USGS official soil series descriptions 9OSDD) for Angelina and San Augustine Counties (USDA 2004). Volumes were calculated using Coble and Hilpp's [15] cubic foot volume equation, then converted to m^3 ha^{-1}.

Statistical analysis

The three sites were analyzed separately using SAS 9.2 for this randomized block design at 0.10 alpha level. Tree heights and diameters were measured prior to treatments and annually afterwards, and then expanded to a per ha level for analysis. Residual tree density ha^{-1} was analyzed using a two-way analysis of variance to confirm that density was not a significant concomitant variable. Volume, QMD, mean heights and BA were also analyzed using a two-way analysis of variance. Growth was represented as last measurement minus first measurement. Tukey's multiple comparison procedure was used to differentiate significant mean treatment effects.

Results

Quadratic Mean Diameter growth (QMD) was significant on two of the three mid-rotation sites, but for different number of years since

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Site	Soil Series	Slope	Taxonomic Class	Site Index (m)
Lufkin	Darco loamy fine sandy	1-8%	Loamy, siliceous, semiactive, thermic Grossarenic Paleudults	24.7
	Sacul fine sandy loam	1-5%	Fine, mixed, active, thermic Aquic Hapludults	25.9
	Teneha loamy fine sand	5-15%	Loamy, siliceous, semiactive, thermic Arenic Hapludults	26.5
Wells	Kirvin gravelly fine sandy loam	1-5%	Fine, mixed, semiactive, thermic Typic Hapludults	25.9
	Woodtell very fine sandy loam	1-5%	Fine, smectitic, thermic Vertic Hapludalfs	23.8
	Woodtell very fine sandy loam	5-15%	Fine, smectitic, thermic Vertic Hapludalfs	24.4
Broaddus	Moswell very fine sandy loam	1-5%	Very fine, smectitac thermic Vertic Hapludalfs	25.6
	Moswell very fine sandy loam	5-15%	Very fine, smectitac thermic Vertic Hapludalfs	24.4

Table 1: Soil series, taxonomic class and site index of the soils at the three sites used in the midrotation fertilizer study.

Site	Chemical Fertilizer Treatment (kg ha^{-1})	Poultry Litter Treatment (kg ha^{-1})	Other Poultry Litter (kg ha^{-1})	Other	Control
Lufkin	224.2 kg N/56.0 P as DAP	To supply 224.0 N with excess P	Poultry litter+Urea 56.0 P, with N	NA	No fertilizer
Wells	224.2 kg N/56.0 P as DAP and Urea	9.0 metric tons	18.0 metric tons	224.2 kg N/56.0 P as DAP and Urea+58.0 K	No fertilizer
Broaddus	224.2 kg N/56.0 P as DAP and Urea	9.0 metric tons	18.0 metric tons	224.2 kg N/56.0 P as DAP and Urea	No fertilizer

Table 2: Fertilizer treatments utilized at the three sites used in the midrotation fertilizer study.

treatment application. On the Broaddus site, the DAP+urea+KCL treatment had a significantly greater effect (p=0.0251) on QMD than the other treatments, but only 4 years after treatment. At the Lufkin site, the low rate of poultry litter+urea resulted in significantly greater QMD (p=0.0883) than the other treatments at the end of the study. No other significant differences were identified for mid-rotation sites.

Discussion

These results confirm the importance of soil properties for influencing tree growth. The lack of significant treatment separation at the Wells site is similar to other results [16,17], while the QMD results at the Broaddus site were also similar to other studies [18,19]. Nitrogen fertilization is typically a short-term amelioration [16] often tied to the pre-fertilization status of the supporting soil, which explains the short-term response found at the Lufkin site, especially when utilizing bio-solids [17].

The lack of significant responses on these sites to most of the treatments confirms a similar lack of response in many other studies [16,20-24]. Since pre-treatment nutritional status was not measured, site quality was estimated using site index based on soil series description. The plot size used in this study (91.4 m × 21.3 m plots) may have not have accurately represented the site quality of these sites as they were classified, and therefore may have partially masked treatment effects. In addition, it is possible that the timeline of this study was too short to allow these treatments to express themselves. Based on the short-term nature of this study, it does appear that for overall growth, poultry litter fertilization is comparable to chemical fertilization [25,26].

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